Correspondence

COMMENTS ON "ON THE STRUCTURE OF PRESSURE SYSTEMS"

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In section 3 of their recent paper, Haltiner, Alden, and Rosenberger [1] indicate that the divergent wind component may be obtained directly from the continuity equation. Since this statement occurs in the same paragraph with a reference to the existence of integral constraints on simplifications of the meteorological equations, it seems pertinent to note that their statement is not strictly valid.

Spar [2] noted in section 6.3 of his paper that the integral constraints imposed by the conservation of energy demand that the "omega" and continuity equations be treated as a coupled system in the two unknowns, the vertical p-velocity and the velocity potential. The numerical complexity of such a system makes it more desirable to use a primitive, baroclinic model in an effort to describe the physical significance of thermal advection by the irrotational component of the horizontal wind.

REFERENCES

1. G. J. Haltiner, R. F. Alden, and G. C. Rosenberger, "On the Structure of Pressure Systems", *Monthly Weather Review*, vol. 93, No. 5, May 1965, pp. 297–305.
2. J. Spar, "A Vertically Integrated Wet, Diabatic Model for the Study of Cyclogenesis", *Proceedings of International Symposium on Numerical Weather Prediction in Tokyo*, Meteorological Society of Japan, Tokyo, 1962, pp. 185–204.

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REPLY

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Mr. J. P. Gerrity, Jr. questions our utilization of the continuity equation for the determination of the velocity potential of the divergent wind from the vertical velocity. Reference is made to integral constraints required of simplifications of the meteorological equations. These constraints were mentioned in our article, but not discussed since they are quite well known from the articles of Winn-Nielsen [3] and others. In brief, relationships may be derived from the system of hydrodynamical equations which demonstrate the conservation of energy, vorticity, etc. It follows that simplifications of these equations (and also their finite-difference analogs) should retain these conservation properties. If the models do not, there may be spurious sources of energy or vorticity which can lead to significant errors when the equations are integrated with respect to time, particularly over long periods.

However, in the computations reported on in our paper, no time integrations are involved. The vertical velocities were merely used to obtain an estimate of the divergent wind through solution of the diagnostic continuity equation. As a prediction model, this procedure would not be strictly consistent because of the quasi-geostrophic approximation utilized in the solution of the ω-equation. However, the resulting ω's are believed to be a fair representation of the large-scale vertical velocity and, in turn, the divergent winds and corresponding thermal advection are approximately correct, at least of the right order of magnitude. The latter was the only inference drawn from the results of the computations and is still considered to be valid.

As a matter of fact, time integrations of a day or so of some simplified models which are not strictly consistent with respect to vorticity or energy conservation, may show no more serious discrepancies than similar consistent models (see Bengtsson [1] and Haltiner [2]).

Whether a primitive equation model would yield a more accurate estimate of the divergent wind component certainly would depend on the specific modeling assumptions, number of levels, initial conditions, etc. Nevertheless, it is agreed that a primitive system is fundamentally simpler than the corresponding derived system consisting of the vorticity equation, divergence equation, etc. It would be of interest to compare thermal advection in two analogous models.

REFERENCES

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2. G. J. Haltiner, "Computer Applications in Environmental Prediction," *Proceedings* 8th Navy Science Symposium, U.S. Navy, 1964.
3. A. Wiin-Nielsen, "On Certain Integral Constraints for the Time Integration of Baroclinic Models," *Tellus*, vol. 11, No. 1, Feb. 1959, pp. 45–59.

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